INVESTIGATING FLUSH SYSTEM METHOD FOR MINIMUM WATER USAGE OF TOILET SYSTEM

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This project is dedicated to my beloved wife, parents and siblings. Thank you for the love, support and courage.

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ABSTRACT

A major concern for most people these days is the use and availability of clean water. With 83 million more people on Earth each year, demands for clean water will keep on rising. Water is everywhere and also important to living things on Earth. But because of the global warming and pollution, water has become deficit in many parts of the world. It can be foreseen that one day water will become a very valuable asset for countries in the future as energy is now. In this study, focus will be given more on the effect of water tank designs in reducing the volume of water usage in toilet system. Testing was divided into two sections that were experimental study and simulation study. First, experimental study conducted to test the performance of four different types of tanks and results are recorded. After that, simulation study conducted and data was recorded. The parameters of the study were the effect of depth of water and design of the water tanks towards pressure and volume flow rate of the water. Based from the test results, comparison was calculated. With percentage error below than 5 percent, it has been determined that simulation study was indeed suitable for this study. To achieve the objectives of this study, the change in design of water tank was proposed to minimize the amount of water used without sacrificing the performance of the toilet. By modifying the water tank designs, the amount of water used inside the tank can be decreased. From simulation study that has been conducted for two design concepts, pressure exerted from the tanks only lost a little amount of energy. As conclusion, by changing the design of water tanks without changing the water level, one could help reduce the amount of water used for flushing his waste. At the same time, it will not affecting the performance of the whole toilet system.

ABSTRAK

Satu kebimbangan utama bagi kebanyakan penduduk dunia pada hari ini ialah penggunaan serta bekalan air bersih. Dengan lebih daripada 83 juta orang di lahirkan setiap tahun, permintaan untuk air bersih akan terus meningkat. Air boleh di dapati di mana-mana jua dan amat penting untuk kehidupan di Bumi. Tetapi disebabkan pemanasan global serta pencemaran, air telah menjadi berkurangan di kebanyakan tempat. Boleh diramalkan bahawa suatu hari nanti air akan menjadi aset yang amat berharga bagi sesebuah negara pada masa akan datang sebagaimana permintaan untuk tenaga pada masa sekarang. Dalam kajian ini, tumpuan akan lebih diberikan kepada kesan reka bentuk tangki air dalam mengurangkan jumlah penggunaan air bagi keseluruhan sistem tandas. Ujian akan dibahagikan kepada dua bahagian iaitu kajian eksperimen dan simulasi. Kajian eksperimen dijalankan untuk menguji prestasi empat jenis tangki dan keputusan direkodkan. Kemudian, kajian simulasi dijalankan dan data direkodkan. Parameter kajian ini ialah kesan kedalaman air serta reka bentuk tangki air terhadap tekanan dan kadar aliran isipadu air. Berdasarkan dari keputusan ujian, perbandingan telah dikira. Dengan ralat peratusan bawah daripada 5 peratus , ia membuktikan bahawa kajian simulasi sememangnya sesuai untuk kajian ini. Bagi mencapai objektif kajian, perubahan dalam reka bentuk tangki air telah dicadangkan untuk mengurangkan jumlah air yang digunakan tanpa mengorbankan prestasi tandas. Dengan mengubah reka bentuk tangki air, jumlah air yang digunakan di dalam tangki dapat dikurangkan. Dari kajian simulasi yang telah dijalankan terhadap dua konsep reka bentuk, didapati hanya sedikit kehilangan tekanan sahaja yang dikesan. Kesimpulannya, dengan menukar reka bentuk tangki air tanpa mengubah paras air, ia dapat membantu mengurangkan jumlah air yang digunakan untuk mengepam keluar bahan buangan. Pada masa yang sama, ia tidak akan memberi kesan kepada prestasi keseluruhan sistem tandas.

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LIST OF SYMBOLS AND ABBREVIATIONS

W.C	Water Closet
HET	High Efficiency Toilet
WSAP	Water Efficient Appliances and Plumbing
MaP	Maximum Performance Test
CAD	Computer Aided Design
CFD	Computer Fluid Dynamics
SI	Standard International Units
SPAN	Suruhanjaya Perkhidmatan Air Negara
WEPLS	Water Efficient Products Labeling Scheme
ΔP	Change of Pressure
P	Pressure
F	Force
A	Area
ρ	Density of Fluid

g	Gravitational Acceleration
h	Elevation/Depth
γ	Specific Weight of the Fluid
Pa	Pascals
Nm^{-2}	Newton per square meter area

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CHAPTER 1

INTRODUCTION

1.1 Water Crisis

A major concern for most people these days is the usage and availability of water. Malaysians spends a large portion of water compared to other consumers in the region. The findings of a study made available to the New Sunday Times (2010), Malaysians wasted the most water that is 226 liters average per day, compared with 155 liters in Singapore and 90 liters in Thailand. And from the same survey, 70 per cent of Malaysians were not likely or not very likely to reduce water usage in their homes in the next three years.

From the other survey, the major water consumption in houses in Australia are water compartment, shower and laundry whereby contributing to 32%, 26% and 21% respectively (Cummings, Wright, & Bonollo, 2001). Thus, the idea of reducing the amount of water used by the water closet (W.C.) seems to offer great potential to reduce overall water usage.

1.2 High Efficiency Toilets

According to National Geographic Magazine (April 2010 issues), with 83 million more people on Earth each year, water demand will keep going up unless we change how we use it. Other facts from this magazine are that in 15 years, 1.8 billion people will live in regions of severe water scarcity.

Water is everywhere and also important to living things on Earth. But because of the global warming and pollution, water has become deficit in many parts of the world. Preserving water nowadays has become an important issue for many countries. According to Cheng, Lee, Liu, & Hsia (2010) it can be foreseen that water will become a very valuable asset for countries and areas in the future as energy is now.

According to McDougall & Wakelin (2007), the increasing importance of water conservation has led to renewed interest in the possibilities for reductions in overall building use through reduced W.C. flush volume operation. Thus, improving water efficiency in home can decrease the water usage and at the same time can save a lot of money. In Australia, they have realize that the most water consume for in-house usage is from the water closet (Figure 1.1). Hence, Australia has established the Water Efficient Appliances and Plumbing group (WEAP) which is responsible to encourage reduction in the volumes of water used by bathroom application (Cummings, Wright, & Bonollo, 2001).

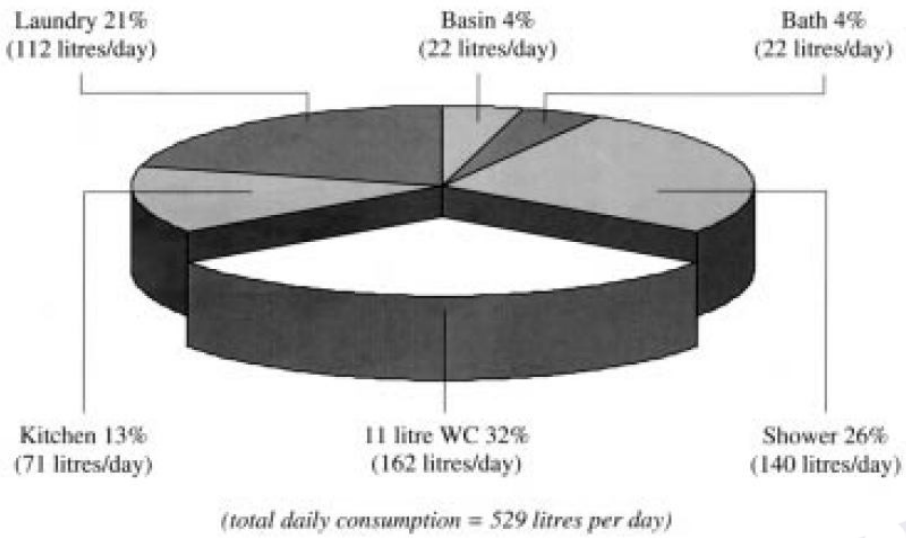

Figure 1. 1: In-house water consumption in a typical Australia (Cummings, Wright, & Bonollo, 2001)

Today, toilet research and development has brought us High-Efficiency Toilets (HET). From continuous usage of this device we can save a lot of water while still maintaining the ability to get the job done. According to director of product for American Standard Brands and Globe Union Group, both of them agree that HET are toilets that use at least 20 percent less water than a standard 1.6 gallons per flush toilet (The Reeves Journal Staff, 2012). From the calculation (shown below) we can conclude that the maximum water usage for HET is only 1.28 gallons which is equivalent to 5.82 liters of water.

$$\frac{20}{100} \times 1.6 \text{ gallons} = 0.32 \text{ gallons}$$

$$1.6 \text{ gallons} - 0.32 \text{ gallons} = 1.28 \text{ gallons } (5.82 \text{ liters})$$

The difference between the HET and standard toilets is that HET use less water per flush. There are a variety of high efficiency toilets available in the market. Among many, the three types that most preferred by consumers are Dual Flush Toilets, Ultra Low Flow (ULF) Toilets, and Waterless Urinals.

1.3 Dual Flush Toilets vs. Ultra-Low Flow Toilets

The dual flush toilet system incorporates two flushes, full flush for solids and a partial flush for liquids. The full flush typically uses full 6 liters (1.6 gallons) of water and the partial flush is between 3 to 3.8 liters (0.8 to 1.0 gallons) of water. There are two types of dual flush system which are gravity assisted and pressurized system. The differences between them is the gravity assisted relies on gravity pulling the water out from the tank and help to get rid of the waste. Meanwhile a pressurized system incorporates a system in pumps inside the tank to force the water into the bowl and eliminate the waste into the drain system.

Meanwhile, the Ultra-Low Flow Toilets are extremely efficient and use only 3 liters (0.8 gallons) of water per flush. The system used a vacuuming effect which is the combination of air and water efficiently to get rid of the waste. When the toilet is flushed, the water from the tank enters the bowl causing pressure to build on the trapway. The trapway allows wastewater to exit and creating the vacuum effect. One of the examples of the ultra-low flow toilets is The Stealth UHET (Ultra High-Efficiency Toilet) which utilizes an air transfer system to achieve better performance.

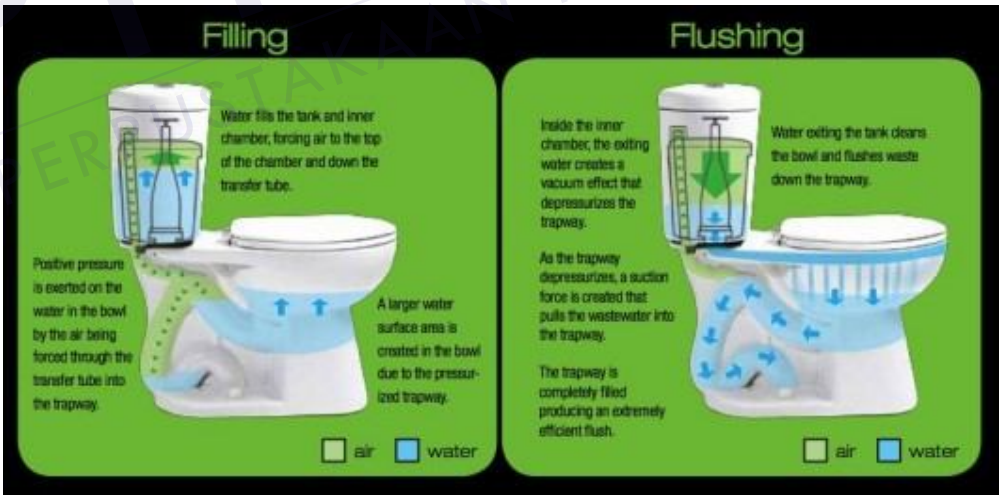

Figure 1. 2: Niagara Stealth Toilet (www.gizmag.com)

Currently, the dual flush toilet system owes its popularity to its water saving properties, reliability, and simplicity resulting in relatively low monthly bill payments. First developed in one of the driest continents that are Australia, today it has been widely used in many countries in Europe and Asia. The principle behind dual flush toilets is that less water is used to flush liquids from the bowl than is used when flushing solids. Liters per flush depend on the model and the manufacturer.

1.4 Research Background

Disposal of human waste has been an issue since humans have inhabited the Earth. In the prehistoric time, men relieved themselves out of the door such as at the rivers, woods and shrubs to answer the nature's call. In 1596, Sir John Harrington of England invented the first flush toilet. Nearly 200 years after that, in 1775 an inventor named Alexander Cummings received the first patent for a water closet (Kravetz, 2009). And since then, the evolutions of flush toilet continued. Nowadays, all toilets manufactured after the year 1995 came in many water-saving options and perform as better as or even better than the older models. Most of them use no more than 7.27 liters per flush while the older ones utilized as much as 22.73 liter per flush!

Assuming that homes built before 1995 and the toilets were those of the old-fashioned ones, the toilet tanks most probably used 16 liters (3.5 gallons) or 23 liters (5 gallons) of water. Though the uses of water by individuals are different, in this case we assume that the user will flush the toilets 3 times a day. By multiplying 3.5 gallons (15.91 liter) of water by the number of times per day we can determine the total volume of water used to flush the toilet each day by a person based on the calculation as follow:

$$3.5\,\text{gallons} \times 4\,\text{flushes} = 14\,\text{gallons}\,(63.65\,\text{liter})$$
$$14.0\,\text{gallons} \times 7\,\text{days} = 98\,\text{gallons}\,(445.52\,\text{liter})$$
$$98\,\text{gallons} \times 4\,\text{weeks} = 392\,\text{gallons}\,(1{,}782.07\,\text{liter})$$
$$392\,\text{gallons} \times 12\,\text{months} = 4{,}704\,\text{gallons per year}\,(21{,}384.82\,\text{liter})$$

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